

Filed by Express Mail
(Receipt No. 8136872205)
on 9/1/99
pursuant to 37 C.F.R. 1.10.
by Sam S. G2

SPECIFICATION

TITLE OF THE INVENTION

CROSS-CONNECT METHOD AND CROSS-CONNECT APPARATUS

5

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to a cross-connect method and a cross-connect apparatus suitable for use with a synchronous digital hierarchy (SDH) transmission system.

(2) Description of the Related Art

A ring network (hereinafter sometimes simply referred to as a "ring") generally comprises a plurality of node devices (SDH transmission devices) connected together by means of high-speed transmission paths (for work and for protection).

Each of the node devices constituting the ring network [for example, an add-and-drop multiplexer (ADM)] is arranged so as to be able to receive a signal sent from another low-speed network of a lower hierarchical level by way of a low-speed transmission path and to add the signal to a high-speed transmission path (transmission path for work) so as to transmit the signal to another node device connected to the ring; to permit a signal—which is transmitted from another node device connected to the ring by way of the

high-speed transmission path—to pass through to
another node device; and to drop a signal to a low-
speed network by way of a low-speed transmission path
and through employment of drop control. An SDH frame
5 of a higher-order group is transmitted over a high-
speed transmission path provided in the ring network,
and a signal received from a lower hierarchical level
is inserted into a payload of the SDH frame.

In the field of the ring network, there has been
10 conceived a uni-directional protection switched ring
(UPSR) which, in the event of a failure in a transmission
path over which a signal is transmitted from a certain
node device, can switch a transmission path to another
transmission path by means of automatic path switching
15 (APS) control, as if the failure had not occurred.

In the UPSR-type ring network, identical signals
are transmitted to a high-speed transmission path for
work (hereinafter often referred to simply as a "path-
for-work") and a high-speed transmission path for
20 protection (hereinafter often referred to simply as a
"path-for-protection"), and a receiving apparatus
monitors the quality of the signals (i.e., line
quality) transmitted over the respective paths and, by
means of a path switch, selectively outputs the signal
25 having better quality.

In contrast with the UPSR-type ring network,
there has been conceived a ring network of bi-

directional line switched ring (BLSR) type. In the BLSR-type ring network, a signal is transmitted to the path-for-work at the time of normal operation. However, in the event of a failure, the signal which is being transmitted to the path-for-work is also transmitted to the path-for-protection.

In the BLSR-type ring network, a service selector of a receiving node device selects a signal—which is transmitted over the path for work—at the time of normal operation but selects a signal—which is transmitted over the path for protection—in the event of a failure, thus switching the transmission path between the path-for-work and the path-for-protection.

As mentioned above, the UPSR-type ring network and the BLSR-type ring network are now available. There has already been conceived a network system which is equipped with both the path switch and the service selector and which is compatible with both the ring UPSR-type network and the BLSR-type ring network.

For instance, a node device 10-1 shown in FIG. 11 is arranged so as to be compatible with both the UPSR-type ring network and the BLSR-type ring network. As shown in FIG. 11, the node device 10-1 comprises time slot assignment sections (TSA) 10-1a, 10-1b, and 10-1c; a path switch (PSW) 10-1d; a time slot interchange (TSI) section 10-1e; and service selectors (S.S) 10-1f and 10-1g.

In the node device 10-1, the TSA sections 10-1a and 10-1b (soft switch) and the path switch (hard switch) change the path over which a signal is dropped from a line. After having been subjected to path
5 switching operation, the signal is reduced in capacity to one-half as large as that of before cross-connect operation (i.e., soft switch).

The TSI section (cross-connect apparatus and soft switch) 10-1e and the service selectors 10-1f and
10 10-1g (hard switch) subject to service selector processing a signal added to the line or a signal passed therethrough, with the result that the signal is reduced in capacity to half that before the service selector processing.

15 The TSA sections 10-1a to 10-1c and the TSI section 10-1e perform operations only through line setting (soft switch) by means of software. As shown in FIG. 11, in a case where a hard switch, such as the path switch 10-1d or the service selectors 10-1f and
20 10-1g, is used, selection of the data on which a cross-connect operation has been performed (or that have been subjected to protection switching by use of a hard switch) is executed in connection with both a signal transmitted over the path for work and a signal
25 transmitted over the path for protection.

In this case, the TSI section 10-1e performs a cross-connect operation on a received signal and

transmits the thus-received signal to the service
selectors 10-1f and 10-1g. In some cases, the signal
on which a cross-connect operation has been performed
is not selected by the service selectors 10-1f and 10-1g.
5 Further, the PSW 10-1d is arranged to select a signal
output from either the TSA 10-1a or the TSA 10-1b and
outputs the thus-selected signal. A redundant
configuration enables a cross-connect operation on a
signal which is not output from the PSW 10-1d, the signal
10 selector 10-1f, or the signal selector 10-1g, thereby
raising a problem of excessive power consumption.

SUMMARY OF THE INVENTION

The present invention has been conceived in view
15 of the above-described problem, and the object of the
present invention is to provide a cross-connect method
and a cross-connect apparatus, both of which apply a
cross-connect operation in place of a function of the
hard switch that has conventionally been used for a
20 purpose other than a cross-connect operation, by
selection of line setting information used for path
switching or service selection and by changing a
cross-connect operation through use of the line setting
information signal, thereby preventing redundant
25 configuration of the cross-connect apparatus.

The present invention provides a cross-connect
method for performing a cross-connect operation on a

main signal which includes a signal transmitted over a path for work and a signal transmitted over a path for protection, and the method comprising a step of retaining line setting information required for the cross-connect operation and a step of controlling the cross-connect operation of the main signal based on the line setting information, wherein the cross-connect operation is controlled in such a manner that one of the path-for-work signal and the path-for-protection signal is to be selectively output.

According to the cross-connect method, the cross-connect control is performed in the step of controlling in a way so as to select the signal of better quality from the path-for-work signal transmitted over the path-for-work and the path-for-protection signal transmitted over the path-for-protection, based on the line setting information retained in the step of retaining. The function of the hard switch that has conventionally been used for a purpose other than cross-connect operation can be applied to cross-connect operation, thereby preventing redundant configuration of the cross-connect apparatus and diminishing power consumption.

Further, the present invention provides a cross-connect apparatus which comprises a cross-connect section for a cross-connect operation on a main signal that includes a path-for-work signal

transmitted over a path for work (hereinafter referred to simply as a "path-for-work signal") and a path-for-protection signal transmitted over a path for protection (hereinafter referred to simply as a

5 "path-for-protection signal"), a memory section for retaining line setting information required for the cross-connect operation and a cross-connect control section for controlling the cross-connect operation performed by the cross-connect section. The cross-

10 connect control section is configured so as to control the cross-connect operation performed in the cross-connect section such that one of the path-for-work signal and the path-for-protection signal is selectively output.

15 In the cross-connect apparatus according to the present invention, the cross-connect control section controls the cross-connect operation of the cross-connect section so as to select the signal of better quality from the path-for-work signal and the path-

20 for-protection signal, through use of the line setting information retained in the memory section, thus diminishing power consumption.

BRIEF DESCRIPTION OF THE DRAWINGS

25 FIG. 1 is a block diagram showing an aspect of the present invention;

FIG. 2 is a block diagram showing a cross-connect

apparatus according to one embodiment of the present invention;

FIG. 3(a) is a schematic representation showing an example of data output from a concatenation
5 detection section;

FIG. 3(b) is a schematic representation showing an example of data output from a concatenation TSI section;

FIG. 4(a) is a schematic representation showing
10 an example of data output from an alarm detection section;

FIG. 4(b) is a schematic representation showing an example of data output from an alarm TSI section;

FIG. 5 is a schematic representation showing an
15 example of line setting information output from an ACM according to one embodiment of the present invention;

FIG. 6 is a schematic representation showing an
example of line setting information output from the ACM to an ACM selector according to one embodiment of the
20 present invention;

FIG. 7 is a schematic representation showing an
example of selection information output from a selector control section to the ACM selector according to one
embodiment of the present invention;

FIG. 8 is a table for describing determination
25 of a received code performed by the selector control section according to one embodiment of the present

invention;

FIGs. 9(a) to 9(e) are tables for describing definitions used by the selector control section for perceiving the code of concatenation according to one embodiment of the present invention;

FIG. 10 is a table for describing determination of concatenation performed by the selector control section according to one embodiment of the present invention; and

FIG. 11 is a block diagram showing one example of configuration of a node device compatible with both a UPSR-type ring network and a BLSR-type ring network.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(a) Aspects of the Present Invention

A cross-connect method according to the present invention comprises a step of retaining line setting information required for a cross-connect operation and a step of controlling the cross-connect operation of a main signal based on the line setting information in such a manner that one of a path-for-work signal transmitted over a path-for-work and a path-for-protection signal transmitted over a path-for-protection is to be selectively output.

Under the cross-connect method according to the present invention, the cross-connect control is performed in the step of controlling in a way so as to

select a signal of better quality from the signal transmitted over the path for work and the signal transmitted over the path for protection based on the line setting information. The function of the hard switch that has conventionally been used for a purpose other than a cross-connect operation can be applied to cross-connect operation, thereby preventing redundant configuration of the cross-connect apparatus and diminishing power consumption.

10 The aspect of the present invention will now be described by reference to the accompanying drawings.

FIG. 1 is a block diagram showing the aspect of the present invention. In FIG. 1, a cross-connect apparatus 1 comprises a cross-connect section 2 for performing a cross-connect operation on a main signal including a signal transmitted over a path for work (hereinafter referred to simply as a "path-for-work signal") and a signal transmitted over a path for protection (hereinafter referred to simply as a "path-for-protection signal"), a memory section 3 for retaining line setting information required for performing the cross-connect operation and a cross-connect control section 4 for controlling the cross-connect operation performed in the cross-connect section 2. The cross-connect control section 4 is configured so as to control the cross-connect operation performed in the cross-connect section 2 such that one

of the path-for-work signal and the path-for-protection signal is selectively output.

In the cross-connect apparatus 1 according to the present invention, the cross-connect control section
5 4 controls the cross-connect operation of the cross-connect section 2 so as to select the signal of better quality from the path-for-work signal and the path-for-protection signal through use of the line setting information retained in the memory section 3,
10 thus diminishing power consumption.

The cross-connect control section 4 further comprises an alarm detection section for detecting alarm information from the signal; an alarm information cross-connect section for performing a cross-connect
15 operation on the alarm information which has been detected by the alarm detection section based on the line setting information retained in the memory section 3; and a switch control section for generating, based on the alarm information performed by the alarm
20 information cross-connect section, a selection information specifying which one of the path-for-work signal and said path-for-protection signal should be selected for output. The cross-connect section 2 may also be arranged to control cross-connect operation of
25 the cross-connect section 2 based on the selection information output from the switch control section.

In the cross-connect apparatus 1 according to the

present invention, the alarm information cross-connect section performs cross-connect operation on the alarm information detected by the alarm detection section to the line setting information retained in the memory section 3, and based on the selection information specifying which of the path-for-work signal or the path-for-protection signal is selected, the switch control section controls cross-connect operation, thus preventing redundant cross-connect processing of the main signal and hence diminishing power consumption.

The alarm detection section may also be arranged to encode the detected alarm information in accordance with a predetermined priority. The switch control section may also be arranged to generate selection information through use of the encoded alarm information on which the cross-connect operation has been performed by the alarm information cross-connect section.

In the cross-connect apparatus 1 according to the present invention, the alarm detection section encodes the detected alarm information in a predetermined priority. The switch control section outputs selection information through use of the encoded alarm information on which the cross-connect operation has been performed by the alarm information cross-connect section. Consequently, the cross-connect apparatus 1 can interface only the important alarm information,

thereby avoiding complication of the interface and realizing a simplified cross-connect apparatus.

The cross-connect control section 4 may also be equipped with a concatenation information detection
5 section for detecting concatenation information relating to combination of header data and subsequent data, and a concatenation information cross-connect section for performing a cross-connect operation on the concatenation information which has detected by the
10 concatenation information detection section in accordance with the line setting information retained in the memory section 3. The switch control section may also be configured to generate selection information based on the concatenation information as
15 the result of the cross-connect operation of the concatenation information cross-connect section and the alarm information as the result of the cross-connect operation of the alarm information cross-connect section.

20 In the cross-connect apparatus according to the present invention, the concatenation information cross-connect section performs cross-connect operation on the concatenation information which has been detected by the concatenation information
25 detection section according to the line setting information retained in the memory section 3. Based on the concatenation information on which the

cross-connect operation has been performed by the concatenation information cross-connect section and the alarm information on which the cross-connect operation has been performed by the alarm information cross-connect section, the switch control section
5 outputs selection information. As a result, concatenation switching control can be performed immediately, thereby diminishing a signal loss and immediately performing alarm switching operation
10 through concatenation.

In addition, the concatenation information detection section may be arranged to encode the detected concatenation information. Further, the switch control section may also be arranged to generate
15 selection information, based on the concatenation information which has been encoded by the concatenation information detection section and on which the cross-connect operation has been performed by the concatenation information cross-connect section.

In the cross-connect apparatus 1 according to the present invention, the concatenation information detection section encodes the detected concatenation information, and the switch control section outputs selection information through use of the concatenation
20 information which has been encoded by the concatenation information detection section and on which the cross-connect operation has been performed by the
25

concatenation information cross-connect section,
thereby avoiding complication of an interface and
realizing a simplified cross-connect apparatus.

Desirably, the cross-connect control section 4
5 is arranged to subject the subsequent data of the
concatenation information to execute the same
cross-connect control as the header data.

In the cross-connect apparatus 1 according to the
present invention, the cross-connect control section
10 4 also subjects the subsequent data to execute the same
cross-connect control as the header data.

Consequently, concatenation switching control can be
performed immediately, thereby diminishing a signal
loss and immediately performing alarm switching
15 operation.

(b) Description of an Embodiment of the Present Invention

An example of the present invention will be
described by reference to the accompanying drawings.

20 An embodiment of the present invention will now
be described by reference to the accompanying drawings.

FIG. 2 is a block diagram showing a cross-connect
apparatus according to one embodiment of the present
invention. A cross-connect apparatus 10 shown in FIG.
25 2 performs a cross-connect operation on a signal having
N (N is an integer) input channels to a (main) signal
having M (M is an integer) output channels and performs

path switching and service selecting operations for selecting the signal of better quality from the path-for-work signal and the path-for-protection signal, and outputting the thus-selected signal. The relationship between the number of input channels N and the number of output channels M is dependent on the setting of the cross-connect apparatus or the network performed by a maintenance engineer and is defined as $N=M$ or $N>M$.

As shown in FIG. 2, the cross-connect apparatus 10 comprises a main signal TSI section 20, a path setting section 30, a switch trigger detection section 41, a switch trigger cross-connect section 42, a selector control section 43, and an ACM selector 44. The following explanation will be based on the assumption that the main signal is transmitted in the form of an STS-12c frame; that signals for 12 channels are superimposed on one frame; and that the cross-connect apparatus 10 outputs $N/12$ SDH transmission frames (STS-12c) as $M/12$ frames.

The main signal TSI section (cross-connect section) 20 performs a cross-connect operation on the main signal included in each SDH transmission frame (hereinafter often referred to simply as an "SDH frame" or a "transmission frame") for each channel to a desired output channel based on the line setting information output from the path setting section 30.

Symbol "N:M" shown in FIG. 2 denotes that the main signal TSI section 20 outputs M channels in response to inputs of N channels.

5 The switch trigger detection section 41 detects trigger information representing a timing for performing path switching and a timing for performing service selection processing and detects concatenation information and alarm information as trigger information.

10 As shown in FIG. 2, the switch trigger detection section 41 comprises a concatenation detection section 41A and an alarm detection section 41B.

15 The concatenation detection section (or concatenation information detection section) 41A detects concatenation information representing that a main signal included in an SDH frame of high-order group is formed by combination of header data and subsequent data. Based on an "H1" byte and an "H2" byte included in a section overhead(SOH) of the SDH frame, the
20 concatenation detection section 41A detects concatenation information and outputs the thus-detected concatenation information after the information has been encoded into a predetermined code such as that provided in Table 1 below.

TABLE 1

ENCODING EXAMPLES

CONCATENATION CODE (CONC CODE)	CONCATENATION SIZE STATUS
000	UNEQ (Unequipped)
001	STS-1
010	STS-3c
011	STS-12c
100	STS-24c
101	STS-48c
110	STS-1 (Protection) *
111	STS-1 (Protection) *

Symbol "*" provided in Table 1 depicts a code which is not set. Further, symbol "000" (UNEQ) represents, for example, concatenation information output to a channel whose line is not set. Accordingly, in the cross-connect apparatus 10, upon receipt of N/12 STS-12c frames, the concatenation detection section 41A detects "011."

FIG. 3(a) represents an example of data output from the concatenation detection section 41A. As shown in FIG. 3(a), the concatenation detection section 41A outputs a code regarding a concatenation size for each channel, in the form of 3 bits of parallel data (i.e., 3 bits of data shown in the left-side column of Table 1 are output in parallel).

For instance, when the cross-connect apparatus 10 receives the STS-12c frame, parallel data output for each channel shown in FIG. 3(a) assume the value "011."

Groups 1, 2, ... N shown in FIG. 3(a) show that STS-12c frames are collected in groups of 12 channels

so as to correspond to the number of channels (12) assigned to one STS-12c frame. Unless otherwise specified, the label "GROUP" provided in other drawings is also used in the same sense.

5 The alarm detection section 41B detects alarm information from a received main signal. In the present embodiment, the alarm detection section 41B encodes the thus-detected alarm information in accordance with a predetermined priority such as that
10 shown in Table 2 and outputs the thus-encoded data. Alarm information may be AIS-P (STS Path Alarm Indication Signal), UNEQ-P (STS Path Unequipped), PLM-P (STS Path Payload Label Mismatch), PDI-P (STS Path Payload Defect Indication), B3 Major (B3 Bit Error
15 Ratio Major Alarm), or B3 Minor (B3 Bit Error Ratio Minor Alarm).

 AIS-P represents an alarm for an STS path level and is determined by detecting that both the "H1" and "H2" bytes of a line overhead assume the value "1."
20 UNEQ-P represents that a line for the STS payload has not yet been set (i.e., a state in which data have not been transmitted) and are determined by detecting that all "C2" bytes in the path overhead assume the value "0."

25 PLM-P represents that the format of data included in the STS payload do not match the format information set in hardware which processes the signal. PLM-P is

determined by comparison between "C2" byte information set in the hardware for processing the signal and a "C2" byte included in the path overhead of the payload.

5 PDI-P represents the number of errors in the data included in the STS payload. The number of errors is encoded, and the thus-encoded number is included in the "C2" byte of the path overhead. PDI-P is determined by the corresponding code.

10 B3 Major and B3 Minor each represent the probability of detection of BIP (bit interleaved parity) errors in the data included in the STS payload. A frequency at which errors are detected ranges from 10^{-3} to 10^{-9} . B3 Major designates data determined to be within the range from 10^{-3} to 10^{-6} , and B3 Minor
15 designates data determined to be outside the range (i.e., within a range over 10^{-9}).

20 (Examples of encoded alarm information are shown in the next page)

TABLE 2

EXAMPLES OF ENCODED ALARM INFORMATION

PRIORITY	ALARM CODE	RECEIVED ALARM STATUS
TOP	11111	AIS-P/UNEQ/PLM-P (EXCLUSIVE OR RESULT)
	11110	B3 Major
	11101	PDI-P (Received "FC _H " code)
	11100	PDI-P (Received "FB _H " code)
	11011	PDI-P (Received "FA _H " code)
	11010	PDI-P (Received "F9 _H " code)
	11001	PDI-P (Received "F8 _H " code)
	11000	PDI-P (Received "F7 _H " code)
	10111	PDI-P (Received "F6 _H " code)
	10110	PDI-P (Received "F5 _H " code)
	10101	PDI-P (Received "F4 _H " code)
	10100	PDI-P (Received "F3 _H " code)
	10011	PDI-P (Received "F2 _H " code)
	10010	PDI-P (Received "F1 _H " code)
	10001	PDI-P (Received "F0 _H " code)
	10000	PDI-P (Received "EF _H " code)
	01111	PDI-P (Received "EE _H " code)
	01110	PDI-P (Received "ED _H " code)
	01101	PDI-P (Received "EC _H " code)
	01100	PDI-P (Received "EB _H " code)
	01011	PDI-P (Received "EA _H " code)
	01010	PDI-P (Received "E9 _H " code)
	01001	PDI-P (Received "E8 _H " code)
	01000	PDI-P (Received "E7 _H " code)
	00111	PDI-P (Received "E6 _H " code)
	00110	PDI-P (Received "E5 _H " code)
	00101	PDI-P (Received "E4 _H " code)
	00100	PDI-P (Received "E3 _H " code)
	00011	PDI-P (Received "E2 _H " code)
	00010	PDI-P (Received "E1 _H " code)
	00001	B3 Minor
LOW	00000	Normal

Priorities provided in Table 2 signify that the lower the priority, the better the quality. If a line is not set for the received main signal, the signal is assigned alarm code "11111" (where the output UNEQ is determined to be identical with UNEQ-P of the alarm status).

FIG. 4(a) shows data output from the alarm detection section 41B. As shown in FIG. 4(a), the alarm detection section 41B outputs alarm information for each channel in the form of 5 bits of parallel data [5

bits of data (alarm code) provided in the left-side column of Table 2 are output in parallel].

The path setting section (memory section) 30 retains line setting information required for the cross-connect operation performed by the main signal TSI section 20. The line setting information is provided for the path-for-work and the path-for-protection. In order to perform "N:M" cross-connect operation, the path setting section 30 is given a register (memory) corresponding to "2M" output channels.

More specifically, as shown in FIG. 2, the path setting section 30 is provided with ACM (address control memory) sections 30-0 and 30-1. The ACM section 30-0 retains line setting information for each channel of the path-for-work (labeled "WORK" in FIG. 2), and the ACM section 30-1 retains line setting information for each channel of the path-for-protection (labeled "PROTECTION" in FIG. 2).

For example, the line setting information corresponds to information representing a linkage between an output channel and an input channel and is used for linking input channels "I" (I=1 to N) to output channels "J" (J=1 to M). The line setting information is sent to a switch trigger cross-connect section 42 and a selector control section 43 from each of the ACM section 30-0 and the ACM section 30-1.

FIG. 5 shows line setting information output from the ACM section 30-0. As shown in FIG. 5, the ACM section 30-0 is arranged to output line setting information for each channel in the form of 10 bits of parallel data. The line setting information for each channel is output from the ACM section 30-0 to each of a concatenation TSI section 42A and an alarm TSI section 42B, which will be described later.

Channel numbers (chl to chM) shown in FIG. 5 represent channels on which cross-connect operation has been performed (i.e., output channels). 10 bits of parallel data output for each output channel represent a channel before cross-connect operation is performed (i.e., an input channel). Accordingly, the line setting information for each channel shown in FIG. 5 is output, for each output channel, in the form of 10 bits of parallel data which represent an input channel (of the path-for-work) linked to the output channel.

The line setting information, which is output from the ACM section 30-1 to the concatenation TSI section 42A and the alarm TSI section 42B (both of which will be described later), is also output for each channel in the form of 10 bits of parallel data, in the same manner as that in which the line setting information is output from the ACM section 30-0 shown in FIG. 5. The line setting information output from the ACM section 30-1 for each output channel also

represents an input channel (of the path-for-protection) linked to the output channel.

FIG. 6 shows an example of line setting information output to the ACM selector 44 from the ACM section 30-0. As shown in FIG. 6, for each channel, 10 bits of parallel data are output to the ACM selector 44 from the ACM section 30-0. The configuration of the parallel data is not specifically shown in FIG. 6, and channel numbers (ch1 to chM) shown in FIG. 6 represent channels on which a cross-connect operation has been performed (i.e., output channels). As in the case of the line setting information (i.e., 10 bits of parallel data) shown in FIG. 5, 10 bits of parallel data output for each channel represent an input channel (of the path-for-work) linked to the output channel.

The line setting information output from the ACM section 30-1 to the ACM selector 44 is also output for each channel in the form of 10 bits of parallel data, as in the case of the line setting information output from the ACM 30-0 shown in FIG. 6, thereby outputting information representing the input channel (of the path-for-protection) linked to the output channel.

At the time of setting of a line, the maintenance engineer for the cross-connect apparatus controls an unillustrated apparatus so as to set and store the line setting information in the ACM sections 30-0 and 30-1.

According to the line setting information (see

FIG. 5) stored in the path setting section 30, the switch trigger cross-connect section 42 performs a cross-connect operation on trigger information detected by the switch trigger detection section 41. More
5 specifically, the switch trigger cross-connect section 42 performs, according to the line setting information retained in the ACM 30-0 and ACM 30-1, a cross-connect operation on the concatenation information and the alarm information in the same manner as the main signal
10 TSI section 20 has performed the cross-connect operation. For example, in a case where the main signal TSI section 20 performs a cross-connect operation on the input channel "I" to the output channel "J," cross-connect operations on the concatenation
15 information and the alarm information, both relating to the input channel "I," are performed to the output channel "J."

To this end, as shown in FIG. 2, the switch trigger cross-connect section 42 is provided with the
20 concatenation TSI section 42A and the alarm TSI section 42B.

On the basis of the line setting information retained in the path setting section 30, the concatenation TSI section (concatenation information cross-connect section) 42A performs a cross-connect
25 operation on the concatenation information detected by the concatenation detection section 41A, thereby

separately outputting to the selector control section 43 the encoded concatenation information relating to the path-for-work and the encoded concatenation information relating to the path-for-protection.

5 FIG. 3(b) shows an example of data output from the concatenation TSI section 42A. The output data shown in FIG. 3(b) are output separately to the selector control section 43 as output data relating to the path-for-work and output data relating to the path-
10 for-protection.

For example, based on the line setting information transmitted from the ACM section 30-0 (see FIG. 5), the concatenation TSI section 42A performs cross-connect operation on concatenation information
15 of N input channels (see FIG. 3(a)) transmitted from the concatenation detection section 41A, thus outputting the data to the selector control section 43 as concatenation information [labeled "Mch (WORK)" in FIG. 2] for the path-for-work.

20 Label "N: (Mx2)" provided in the concatenation TSI section 42A shown in FIG. 2 represents that after the concatenation TSI section 42A has performed a cross-connect operation on a code for N channels transmitted from the concatenation detection section
25 41A, a code for M-channels for the path-for-work and a code for M-channels for the path-for-protection are output.

For example, provided that an input channel (ch3) is used as the path-for-work and that the main signal TSI section 20 performs a cross-connect operation on the input channel (ch3) to an output channel (ch24), the concatenation TSI section 42A performs a cross-connect operation on concatenation information (3 bits of parallel data) relating to the detected input channel (i.e., ch3) to the output channel (ch24), as shown in FIGs. 3(a) and 3(b).

At this time, based on the line setting information held in the ACM section 30-1, the concatenation TSI section 42A performs a cross-connect operation on concatenation information corresponding to the N input channels (see FIG. 3(a)), thus outputting to the selector control section 43 concatenation information for the path-for-protection [labeled "Mch (PROTECTION)b" in FIG. 2].

For example, provided that the input channel (ch23) is used for the path-for-protection and the main signal TSI section 20 performs a cross-connect operation on the input channel (ch23) to the output channel (ch8), the concatenation TSI section 42A performs a cross-connect operation on the concatenation information (3 bits of parallel data) relating to the detected input channel (ch23) to the channel (ch24), as shown in FIGs. 3(a) and 3(b).

Next, based on the line setting information

retained in the path setting section 30, the alarm TSI section (alarm information cross-connect section) 42B performs a cross-connect operation on the alarm information detected by the alarm detection section 41B, thereby separately outputting to the selector control section 43 coded alarm information for the path-for-work and coded alarm information for the path-for-protection.

FIG. 4(b) shows an example of data output from the alarm TSI section 42B. The output data shown in FIG. 4(b) are separately output to the selector control section 43 as output data for the path-for-work and output data for the path for protection. Further, label "N:(Mx2)" provided in the alarm TSI section 42B shown in FIG. 2 represents that after the alarm TSI section 42B has performed a cross-connect operation on a code for N channels transmitted from the alarm detection section 41B, a code for M-channels for the path-for-work and M-channels for the path for protection are output.

More specifically, on the basis of the line setting information transmitted from the ACM section 30-0 (see FIG.5), the alarm TSI section 42B cross-connects the alarm information which are transmitted from the alarm detection section 41B and correspond to the N input channels (see FIG. 3(a)), thus outputting to the selector control section 43 as the alarm

information for the path-for-work [labeled "Mch
(WORK)c" in FIG. 2].

For example, provided that the input channel
(ch3) is used for the path-for-work and the main signal
5 TSI section 20 performs a cross-connect operation on
the input channel (ch3) to the output channel (ch24),
the alarm TSI section 42B performs a cross-connect
operation on the alarm information (5 bits of parallel
data) relating to the detected input channel (ch3) to
10 the channel (ch24), as shown in FIGs. 4(a) and 4(b).

Based on the line setting information for the
path-for-protection (information for use with the
path-for-protection corresponding to that shown in FIG.
5) retained in the ACM section 30-1, the alarm TSI
15 section 42B performs a cross-connect operation on the
alarm information corresponding to N input channels
(see FIG. 4(a)), thereby outputting the information to
the selector control section 43 as alarm information
for the path-for-protection [labeled "Mch
20 (PROTECTION)d" shown in FIG. 2].

For example, provided that the input channel
(ch23) is used as the path-for-protection and that the
main signal TSI section 20 performs a cross-connect
operation on the input channel (ch23) to the output
25 channel (ch8), the alarm TSI section 42B performs a
cross-connect operation on the alarm information (5
bits of parallel data) relating to the detected input

channel (ch23) to the output channel (ch8).

Next, based on the alarm information on which a cross-connect operation has been performed by the alarm TSI section 42B and the concatenation information on which a cross-connect operation has been performed by the concatenation TSI section 42A, the selector control section (switch control section) 43 outputs information for determining (selection information) which of the path-for-work signal and the path-for-protection signal is selected.

Further, the selector control section 43 is also arranged to switch the path switching operation and the service selection operation according to the priority of the alarm, as well as to determine a direction in which switching is performed, based on the setting performed by software. The switching operation and the determination of the switching direction are performed on the basis of two sets of information items corresponding to two channels (i.e., the path-for-work and the path-for-protection) which are input for each channel, each information set comprising alarm information and concatenation information.

Based on these information items, the selector control section 43 performs hard switching and soft switching, thus outputting selection information.

Specifically, the selector control section 43 compares the alarm information items relating to two

input channels linked to one output channel and compares the codes (binary codes, and refer to Table 2) transmitted from the alarm TSI section 42B as alarm information, thereby selecting from the path-for-work
5 signal and the path-for-protection signal the signal whose alarm information has a lower priority.

For example, when "AIS-P" is detected for the work (the path-for-work) and "B3 Minor" is detected for the protection (the path-for-protection) from two
10 respective input channels linked to the output J channel, the selector control section 43 outputs to the ACM selector 44 selection information representing that the work channel should be selected for the line setting information relating to the output J channel,
15 so that a main signal of protection can be output to the main signal TSI section 20.

FIG. 7 shows an example of selection information output from the selector control section 43 to the ACM selector 44. The channel numbers shown in FIG. 7
20 represent output channels of the main signal TSI section 20, and the selection information is output to the ACM selector 44 for each output channel. In the present embodiment, for each output channel, one bit of data; that is, either "0" representing that the
25 path-for-work signal should be output or "1" representing that the path-for-protection signal should be output, are output as a selection signal.

Based on the concatenation information transmitted from the concatenation TSI section 42A, the selector control section 43 is also arranged so as to perform concatenation operation. At the time of execution of the concatenation operation, the selector control section 43 determines whether or not a code appropriate for concatenation information relating to the path-for-work and a code appropriate for concatenation information relating to the path-for-protection have been received.

FIG. 8 is a diagram for describing a determination made by the selector control section 43 as to a received code. FIG. 8 shows the relationship between header data and subsequent data which are joined through concatenation. In the main signal TSI section 20, a maximum of 12 signals (included in the STS-12c frame) can be input per slot. Handling a STS-48c frame requires four slots. As shown in FIG. 8, the following description is based on the assumption that the main signal TSI section 20 has a transmission capacity of eight slots.

Since the cross-connect apparatus 10 handles an STS-12c frame, the subsequent channels (ch2 to ch12) are subordinate to a header channel (ch1), as indicated by arrow A 12c shown in FIG. 8.

In the selector control section 43, only the header channel (ch1) can receive the code for the

STS-12c frame. If the selector control section 43 receives the code for the STS-12c frame over any other channel, the thus-received code is disregarded.

Further, a determination is made as to whether or not
5 the concatenation code of the received code is correct.

FIGs. 9(a) to 9(e) are diagrams for describing the definition used by the selector control section 43 for identifying the concatenation code. Upon receipt of a concatenation size set by the maintenance engineer
10 for the network or the cross-connect apparatus 10, the selector control section 43 identifies the concatenation code according to the definition shown in FIG. 9(a).

When receiving concatenation information whose
15 size is greater than the preset concatenation size, the selector control section 43 handles the thus-received concatenation information as STS-1 for each channel. In a case where the concatenation size is set to the size of the STS-12c frame, if the selector control
20 section detects concatenation information that is greater in size than the STS-12c frame, the concatenation information is handled as STS-1.

For example, if the selector control section 43 detects a code of STS-24c or STS-48c in spite of the
25 fact that the concatenation size of the header channel is set to STS-12c, the thus-detected code is handled as STS-1 (labeled "C" in FIG. 9(c)), as shown in FIG.

9(c).

The selector control section 43 compares the concatenation code for the path-for-work with the concatenation code for the path-for-protection, both
5 being transmitted from the concatenation TSI section 42A, and acknowledges a concatenation code of greater capacity as being the concatenation code for the current channel.

FIG. 10 is a table for describing determination
10 of concatenation made by the selector control section 43, showing selection of a concatenation code in the case where the selector control section 43 receives concatenation codes of different capacities. On the basis of the information shown in FIG. 10, the selector
15 control section 43 determines the capacity of the concatenation code.

For example, if the selector control section 43 detects a concatenation code (STS-1) from EAST and another concatenation code (STS-12c) from WEST with
20 regard to a certain output channel, as indicated by arrow B shown in FIG. 10, the concatenation code (STS-12c) is selected (as indicated by a circle designated by arrow B in FIG. 10).

The term "EAST" provided in FIG. 10 designates
25 either the path-for-work or the path-for-protection. If the signal received over EAST is a path-for-work signal, the term "WEST" corresponds to a path-for-

protection signal. Further, "SS" shown in FIG. 10 represents service selection, and "PSW" represents path switching.

When receiving an appropriate concatenation code of the header channel, the selector control section 43
5 outputs the same selection information as that of the header channel to subsequent channels without comparing alarm information items (i.e., concatenation operation).

10 For example, when the selector control section 43 outputs selection information "0" to the output channel (ch1) shown in FIG. 7, selection information "0" of the header channel (ch1) is duplicated and output to the subsequent channels (ch2 to ch12).

15 Based on the selection information transmitted from the selector control section 43, the ACM selector 44 selects the line setting information items transmitted from the ACM sections 30-0 and 30-1.

Based on the selection information (see FIG. 7)
20 transmitted from the selector control section 43, for each channel the ACM selector 44 selects line setting information from the line setting information items received from the ACM section 30-0 and the ACM section 30-1 and sends the thus-selected line setting
25 information to the main signal TSI section 20.

Selection information which is shown in FIG. 7 and is formed from one bit for each channel is used when

the ACM selector 44 selects the line setting information for the path-for-work or the line setting information for the path-for-protection. The ACM selector 44 converts the selection information—which is shown in FIG. 7 and is transmitted in a serial manner—to parallel data and selects line setting information. If selection information assumes the value "0," the line setting information for the path-for-work is selected. In contrast, if selection information assumes the value "1," line setting information for the path-for-protection is selected.

For example, if selection information of the output channel (chl) shown in FIG. 7 assumes the value "1," the ACM selector 44 selects the line setting information transmitted from the ACM section 30-1 from the line setting information items which are transmitted from the ACM sections 30-0 and 30-1 and which represent input channels linked to the output channels.

The line setting information selected by the ACM selector 44 is again explained by reference to FIG. 6. The line setting information is output as M/12 parallel data and is used for controlling the main signal TSI section 20. More specifically, the line setting information transmitted for each output channel is used as a read address by the main signal TSI section 20 (i.e., the main signal TSI section 20 is controlled by means

of M/12 parallel data).

In the cross-connect apparatus 10, a cross-connect control section is constituted of the concatenation detection section 41A, the alarm
5 detection section 41B, the concatenation TSI section 42A, the alarm TSI section 42B, the selector control section 43, and the ACM selector 44. Through use of the line setting information retained in the path setting section 30, the cross-connect control section
10 controls cross-connect operation performed by the main signal TSI section 20.

The operation of the cross-connect apparatus 10 having the foregoing configuration will now be described in connection with a case where SONET
15 (synchronous optical network) frames of concatenation size 12c (including 12 channels) are received over the path-for-work and the path-for-protection and where a cross-connect operation to output channels (ch1 to ch12) is performed on the thus-received 24 input
20 channels (path-for-works ranging from ch1 to ch12 and path-for-protections ranging from ch13 to ch24).

The signals which are transmitted to the cross-connect apparatus 10 as the path-for-work signal and the path-for-protection signal are sent to the main
25 signal TSI section 20, as well as to the switch trigger detection section 41.

In the switch trigger detection section 41, the

concatenation detection section 41A detects concatenation information from the section overhead of the received main signal and converts the thus-detected concatenation information into a predetermined code.

5 The predetermined code is then sent to the concatenation TSI section 42A.

More specifically, the concatenation detection section 41A detects STS-12c from "H1" and "H2" bytes from the section overhead of each of the received

10 path-for-work signal and the path-for-protection signal, thus outputting concatenation information "011", shown in Table 1 (see FIG. 3(a)).

With regard to the input channels (ch1 to ch12), the same concatenation information (i.e., "011") is

15 output from the concatenation detection section 41A to the concatenation TSI section 42A in the form of a 3-bit parallel signal.

The alarm detection section 41B provided in the switch trigger detection section 41 detects alarm

20 information from the received signal for each channel and converts the thus-detected alarm information into a predetermined code, thereby transmitting the predetermined code to the alarm TSI section 42B (see FIG. 4(a)).

25 Next, through use of the line setting information for the path-for-work transmitted from the ACM section 30-0 and the line setting information for the path-

for-protection transmitted from the ACM section 30-
1 (see FIG. 5), the alarm TSI section 42B performs a
cross-connect operation on the alarm information (see
FIG. 4(a)) transmitted from the alarm detection section
5 41B (see FIG. 4(b)).

As in the case of the cross-connect operation
performed by the alarm TSI section 42B, through use of
the line setting information shown in FIG. 5, the
concatenation TSI section 42A performs a cross-connect
10 operation on the concatenation information (see FIG.
3(a)) transmitted from the concatenation detection
section 41A (see FIG. 3(b)).

Next, based on the concatenation information
transmitted from the concatenation TSI section 42A and
15 the alarm information transmitted from the alarm TSI
section 42B, the selector control section 43 outputs
to the ACM selector 44 selection information represents
which of the line setting information for the path-
for-work and the line setting information for the
20 path-for-protection is selected.

According to the priority shown in Table 2, the
selector control section 43 selects the signal of lower
priority from the two signals transmitted from the
alarm TSI section 42B and compares the concatenation
25 information for the path-for-work with the
concatenation information for the path-for-protection,
both being transmitted from the concatenation TSI

section 42A, thereby outputting as selection information the concatenation information of larger size or greater capacity.

When receiving concatenation information items,
5 the selector control section 43 compares alarm information items, with regard to only the header channel (ch1). For example, if the selector control section 43 determines that the concatenation information for the path-for-protection should be
10 selected, from the result of comparison between the header channel of the path-for-work signal and the header channel of the path-for-protection signal according to Table 2, "1" is output as selection information in relation to the header channel. Even
15 to the channels (ch2 to chl2) subsequent to the header channel (ch1), there is output selection information "1" for selecting the line setting information for the path-for-protection.

At the time of comparison between concatenation
20 information items, when receiving concatenation information whose size is greater than the preset concatenation size, the selector control section 43 handles the thus-received concatenation information as STS-1 for each channel (see FIG. 9(c)).

25 For example, in a case where the work concatenation information [in relation to output channels ch1 to chl2] transmitted from the

concatenation TSI section 42A represents a code of STS-24c, the selector control section 43 handles the work output channels (ch1 to ch12) as STS-1. As a result of comparison of the size of the work concatenation information and the size of the protection concatenation information, STS-1 is found to be of greater size than STS-12c. Hence, STS-12c is selected (see FIG. 10), and selection information items equal in number to the channels included in STS-12c are output to the ACM selector 44.

Even in this case, the selector control section 43 compares alarm information items, with regard to only the header channel (ch1). When determining "1" as selection information in relation to the output channel (ch1), the selector control section 43 outputs "1" as selection information to the subsequent channels (ch2 to ch12).

Subsequently, on the basis of the selection information transmitted from the selector control section 43, for each channel the ACM selector 44 selects either the line setting information transmitted from the ACM section 30-0 or the line setting information transmitted from the ACM section 30-1, and outputs the thus-selected line setting information to the main signal TSI section 20.

More specifically, in a case where the selection information transmitted to the output channels (ch1 to

ch12) from the selector control section 43 is "1," the
ACM selector 44 selects the line setting information
transmitted from the ACM section 30-1 and sends the line
setting information to the main signal TSI section 20
5 (see FIG. 6). In this case, the ACM selector 44 selects
the line setting information transmitted from the ACM
section 30-1 as selection information in relation to
the header channel (ch1) and the subsequent channels
(ch2 to ch12) of the concatenation information and
10 outputs the thus-selected selection information.

Based on the line setting information transmitted
from the ACM selector 44, the main signal TSI section
20 performs a cross-connect operation on the input
channels (ch13 to ch24) to the output channels (ch1 to
15 ch12).

Even with regard to other input channels, the
cross-connect apparatus 10 compares alarm information
items, thereby performing a cross-connect operation on
the input channels to output channels.

20 As mentioned above, in the cross-connect
apparatus 10 according to the present invention, after
a cross-connect operation having been performed, the
main signals transmitted over the path-for-work and the
path-for-protection are not subjected to path
25 switching operation or service selection operation.
Through use of line setting information for the
path-for-work or the path-for-protection selected by

the ACM selector 44 based on the selection information transmitted from the selector control section 43, the main signal TSI section 20 performs a cross-connect operation on only the path-for-work main signal or the path-for-protection main signal, thus performing path switching and service selection operations.

In the cross-connect apparatus 10, the function of the hard switch that has conventionally been used for a purpose other than cross-connect operations can be applied to a cross-connect operation, thereby preventing redundant configuration of the cross-connect apparatus and diminishing power consumption.

Further, in the cross-connect apparatus 10 according to the present invention, the alarm TSI section 42B performs a cross-connect operation on the alarm information detected by the alarm detection section 41B, according to the line setting information retained in the path setting section 30. Based on the selection information representing which of the main signal output over the path-for-work and the main signal output over the path-for-protection is selected, the selector control section 43 controls the cross-connect operation of the main signal TSI section 20, with the result that redundant configuration of the cross-connect apparatus can be prevented and power consumption can be diminished.

In the cross-connect apparatus 10 according to

the present invention, the alarm detection section 41B encodes the detected alarm information in the predetermined priority shown in Table 2. The selector control section 43 outputs selection information
5 through use of the encoded alarm information on which a cross-connect operation has been performed by the alarm TSI section 42B. Consequently, the cross-connect apparatus 10 can interface only the important alarm information, thereby avoiding complication of
10 the interface and realizing a simplified cross-connect apparatus.

In the cross-connect apparatus 10 according to the present invention, the concatenation TSI section 20 performs a cross-connect operation on the
15 concatenation information detected by the concatenation detection section 41A according to the line setting information retained in the path setting section 30. Based on the concatenation information on which a cross-connect operation has been performed by
20 the concatenation TSI section 42A and the alarm information on which a cross-connect operation has been performed by the alarm TSI section 42B, the selector control section 43 outputs selection information. As a result, concatenation switching can be performed
25 immediately, thereby diminishing a signal loss and immediately performing alarm switching through concatenation.

In the cross-connect apparatus 10 according to the present invention, the concatenation detection section 41A encodes the detected concatenation information, and the selector control section 43
5 outputs selection information by use of a code encoded by the concatenation TSI section 42A, thereby avoiding complication of an interface and realizing a simplified cross-connect apparatus.

10 In the cross-connect apparatus 10 according to the present invention, with regard to a signal whose main data and subsequent data are multiplexed, the subsequent data are subjected to the same control as used for performing a cross-connect operation on the header data. Consequently, concatenation switching
15 can be performed immediately, thereby diminishing a signal loss and immediately performing alarm switching.

In the cross-connect apparatus 10 according to one embodiment of the present invention, one group is
20 handled as 12 channels (STS-12c). One group may be handled as, for example, 1 channel (STS-1), 3 channels (STS-3), 12 channels (STS-12c), 24 channels (STS-24c), 48 channels (STS-48c), or the like. In other words, various groups—which differ from one another in terms
25 of the number of channels included in one group—are handled, and a cross-connect operation may be performed on a plurality of signals having different transmission

capabilities.

For example, in consideration for input N channels, the cross-connect apparatus 10 may be arranged to be able to handle 48 channels of N channels
5 as STS-48c, 24 channels as STS-24c, 6 channels as 2STS-3, and the like.

The maintenance engineer for the cross-connect apparatus or the ring network may set a rate at which a signal is input over an input channel of N input
10 channels of the main signal TSI section 20 or a rate at which a signal is output over an output channel of M output channels.

The cross-connect apparatus 10 sends to the main signal TSI section 20 a signal transmitted over a
15 low-speed transmission path as well as a signal transmitted over a high-speed transmission path. In the same manner as described previously, cross-connect operation is performed under control of the path setting section 30, the switch trigger cross-connect
20 section 42, the selector control section 43, and the ACM selector 44.

In this case, since the cross-connect operation performed by the main signal TSI section 20 is different from that described previously, the line setting
25 information held in the ACM sections 30-0 and 30-1 differ from the previously-described line setting information retained in the ACM sections 30-0 and 30-1.

The line setting information changes in various manners according to the settings performed by the maintenance engineer for the cross-connect apparatus or the network. Even in the cross-connect apparatus 10, there are performed a service selection operation and a path switching operation for selecting the main signal from the path-for-work main signal and the path-for-protection main signal and for outputting the thus-selected main signal. The concatenation code output from the concatenation detection section 41A of the switch trigger detection section 41 is performed a cross-connect operation by the concatenation TSI section 42A of the switch trigger cross-connect section 42 based on the line setting information held in the ACM section 30-0. Further, the alarm code output from the alarm detection section 41B of the switch trigger detection section 41 is performed a cross-connect operation by the alarm TSI section 42B on the basis of the line setting information held in the ACM section 30-1. This concatenation on which a cross-connect operation has been performed and alarm codes are output to the selector control section 43.

In this case, the line setting information output from the ACM section 30-0 shown in FIG. 5 to the concatenation TSI section 42A and the line setting information output from the ACM section 30-1 to the alarm TSI section 42B are written so as to output 12

channels per group. However, the number of channels to be output is not limited to 12 but may be 1, 24, or the like.

Similarly, FIG. 3(b) shows the code output from the concatenation TSI section 42A to the selector control section 43, and FIG. 4(b) shows the code output from the alarm detection section 42B to the selector control section 43. The label "GROUP" provided in FIGS. 3(b) and 4(b) is not limited to 12 channels.

Further, the selection information shown in FIG. 7 and the line setting information shown in FIG. 6 are not limited to 12 channels per group.

The cross-connect apparatus handles a plurality of signals which differ from one another in transmission rate. If the selector control section 43 receives a concatenation code of STS-48c over the channel which is set so as to receive a code of STS-24c, the thus-received code is identified as STS-1 (see FIG. 9(b)).

The selector control section 43 also perceives the received concatenation code through use of the data contained in the tables FIGs. 9(d) and 9(e).

The cross-connect apparatus 10 having the foregoing configuration yields the same advantageous results as those described above. Further, the cross-connect apparatus 10 enables a cross-connect operation of signals having various transmission rates

within the maximum number of channels capable of being
handled by the cross-connect apparatus, as well as a
cross-connect operation of signals having a pre-
designed transmission rate. As a result, the
5 cross-connect apparatus can be applied to various
networks and can contribute to improving configuration
of a network.

The present invention may be implemented in the
form of various embodiments other than that which has
10 been previously described in detail, so long as the
embodiments fall within the scope of the invention.